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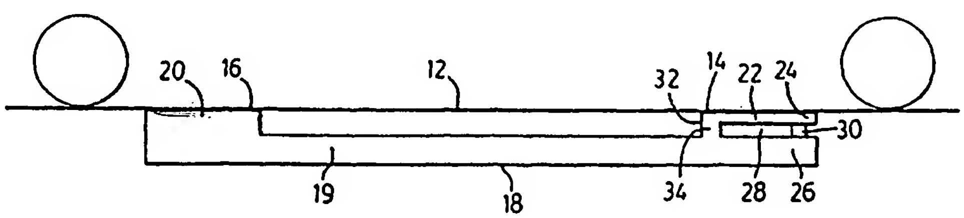

(57) Abstract

The present invention provides a mechanism for controlling the tension of a guided wave fiber Bragg grating (12) device. The tension imposed on a guided wave fiber Bragg grating (12) can be used to control its spectral characteristics as desired. For example, the center wavelength of a fiber Bragg grating (12) can be directly controlled by the tension imposed on the fiber, and in the case of a nonlinearly chirped grating, its effective group delay properties can also be controlled by fiber tension. These examples are directly related to applications in sensing, and in WDM filters and dispersion compensation devices. The tension control mechanism for controlling the spectral properties of a fiber Bragg grating (12) includes a support structure (18) to which the fiber Bragg grating (12) is attached at a first (20) and second (22) portion. The support structure (18) includes an adjustment mechanism (30) whereby adjustment of the support structure in one direction increases tension in the fiber Bragg grating (12) and adjustement of the support structure (18) in the other direction decreases tension in the fiber Bragg grating (12).

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TENSION CONTROL MECHANISM FOR BRAGG GRATING DEVICES

FIELD OF THE INVENTION

The present invention relates to a tension control mechanism for controlling the spectral properties of Bragg gratings.

BACKGROUND OF THE INVENTION

The characteristic optical spectral properties of fiber Bragg gratings and the available techniques to tailor these properties both during and after fabrication allows them to form the basis of a wide variety of devices. These devices include strain, pressure and temperature sensors, spectral filters, and chromatic dispersion compensation devices among others. For example, fiber gratings have been configured to fulfill the optical filtering requirements of high capacity WDM (wavelength division multiplexing) optical transmission systems where its spectral filtering capability is used to isolate optical carriers for the purpose of de-multiplexing and adding or dropping carriers. Specially chirped fiber gratings are also used for the purpose of correcting the chromatic dispersion which exists in many optical transmission systems, particularly in the case of high capacity systems where high speed TDM (time division multiplexing) and long repeater-less links are employed. In sensing applications the sensitivity of the fiber grating spectral characteristics to external influence from physical strain is used to provide a measure of the deformation of various structures such as bridge components or ship hulls.

In many of these applications the fiber Bragg grating must be mounted and packaged in special ways such that it satisfies performance

requirements. For example, the mounting and packaging technique used must fulfill purposes such as the following: providing physical protection, environmental stability, tunability, and attachment to other components. In some applications the characteristic center wavelength of the fiber Bragg grating must be controlled to close tolerances. This requirement may exceed the capability of fiber Bragg grating fabrication or the procedures used in mounting and packaging them. For example, the fiber Bragg grating is often bonded to a substrate and the bonding procedure can induce a change in its center wavelength by an amount that is difficult to predict reliably.

There is therefore a need for a device that will allow fine-tuning of the fiber Bragg grating center wavelength and other spectral characteristics in its mounted and packaged state. This provides for a higher accuracy and greater cost effectiveness in fiber Bragg grating device manufacture.

SUMMARY OF THE INVENTION

The present invention relates to an adjustable tension control device that will allow fine-tuning of the fiber Bragg grating center wavelength and other spectral characteristics after the Bragg grating has been attached or bonded to a support structure forming part of the mechanism. This provides for a higher accuracy and greater cost effectiveness in fiber Bragg grating device manufacture. This technique may also be used to provide for manufacture of a tunable device, either manually by way of a turn screw or electronically by way of an actuator.

In one aspect of the invention there is provided a tension control

mechanism for controlling the spectral properties of fiber Bragg gratings. The tension control mechanism includes a support structure to which the fiber Bragg grating is attached at a first and second portion. The support structure includes an adjustment mechanism whereby adjustment of the support structure in one direction increases tension in the fiber Bragg grating and adjustment of the support structure in the other direction decreases tension in the fiber Bragg grating.

In another aspect of the invention there is provided a tension controlled fiber Bragg grating assembly for controlling the spectral properties of the Bragg grating. The assembly includes an optical fiber having a Bragg grating attached to an adjustable support structure. The fiber Bragg grating is attached at a first and second portion. The support structure includes an adjustment mechanism whereby adjustment of the support structure in one direction increases tension in the fiber Bragg grating and adjustment of the support structure in the other direction decreases tension in the fiber Bragg grating.

The support structures may include first and second spaced apart supports. Further the support structures may include an adjustable slot. The slot may be positioned in one of the spaced apart supports, along the length of the body or along the width of the body.

BRIEF DESCRIPTION OF THE DRAWINGS

The tension control mechanism for controlling the spectral response of guided wave Bragg grating devices forming the present invention will now be described, by example only, with reference being had to the

accompanying drawings, in which:

Figure 1 is an elevational view of a tension control mechanism constructed in accordance with the present invention;

Figure 2 is an elevational view of a second embodiment of a tension control mechanism constructed in accordance with the present invention;

Figure 3 is an elevational view of a third embodiment of a tension control mechanism constructed in accordance with the present invention;

Figure 4 is a bottom view of the tension control mechanism of Figure 3.

Figure 5 is an elevational view of a fourth embodiment of a tension control mechanism constructed in accordance with the present invention; and

Figure 6 is a top view of the tension control mechanism of Figure 5.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a mechanism for controlling the tension of a guided wave Bragg grating device. The tension imposed on a guided wave Bragg grating can be used to control its spectral characteristics as desired. For example, the center wavelength of a fiber Bragg grating can be directly controlled by the tension imposed on the fiber, and in the case of a nonlinearly chirped grating, its effective group delay properties can be also be controlled by fiber tension. These examples are directly related to applications in WDM filters, in dispersion compensation devices and in sensing. These mechanisms can also be used to adjust the level of compression in devices which maintain the Bragg grating in a state of compression.

The mechanism of the present invention relies on the imposition of

deformation onto the element to which the Bragg grating is attached in such a manner as to achieve a high degree of control of the tension in the grating and hence control of the grating center wavelength or other optical characteristics which can be controlled by tensile strain. The degree of control necessary in many practical implementations is essential to the success of such a device. For common fiber Bragg grating devices, tensile deformations must be controlled within magnitudes of the order of 10 microns. The present invention offers the degree of control necessary to yield such highly accurate tuning. Moreover, tuning of the grating can be accomplished after manufacturing procedures such as Bragg grating fabrication and bonding which are difficult and costly to control to equivalent tolerances.

Referring to Figure 1, in a first embodiment a fiber Bragg grating 12 is mounted on a support structure 18. Support structure 18 includes a body 19 with two spaced apart supports 20 and 22 at each end thereof. The end portions 14 and 16 of fiber Bragg grating 12 are bonded to the two spaced apart supports 22 and 20. Preferably end portions 14 and 16 are bonded as close to the inside edge of supports 20 and 22 as practicable. The middle portion of the grating 12 is freely suspended between supports 20 and 22.

Supports 20 and 22 may serve additional functions such as temperature stabilization, as has been put forth in schemes which utilize the principle of applying a thermally dependent tension on a grating which is attached at its ends to compensating members of various constructions and materials such as U.S. Patent No. 5,042,898, "Incorporated Bragg filter temperature compensated optical waveguide device", Morey, W.W. and Glomb,

W.I. In response to temperature changes these members undergo thermal expansion thereby imposing on the grating the necessary tension adjustment to cancel the inherent thermal effects on the grating center wavelength.

Figure 1 illustrates a means by which the support structure is deformed in a controlled manner to effectively alter the free unsupported length of the fiber containing the Bragg grating thereby increasing or decreasing the tension in the Bragg grating as desired. Support 22 is provided with two spaced apart arms 24 and 26 defining a slot 28 therebetween and the distance between the arms can be adjusted using an adjustment set-screw 30. Adjustment of the adjustment set-screw 30 displaces arm 24 either toward or away from arm 26. The slot 28 in the support 22 between arms 24 and 26 allows the inside edge 32 of the support to rotate counter clockwise when the screw 30 is advanced and clockwise when the screw 30 is retracted. Counter clockwise rotation of edge 32 serves to advance the upper edge to which the optical fiber is bonded and hence reduces the tension in the grating and clockwise rotation of edge 32 has the opposite effect. Accordingly, adjustment of screw 30 causes rotation and bending of the arms 24 and 26 and displacement of the portion 14 of the fiber Bragg grating 12.

The position and depth of the slot 28 and the length and thickness of the slot arms 24 and 26 are designed such that a relatively large displacement of the set-screw 30 produces a very small displacement of the support edge 32. The enhanced control is accomplished by both the relatively large length between the set-screw 30 and the effective hinge at the head 34 of the slot 28, and the compliance of the slot arms 24 and 26. For the tuning to be reversible

this deformation must be accomplished within the elastic range of the material used for support section 22.

In figure 2 a second embodiment of a tension control mechanism is shown in which a fiber Bragg grating 12 is mounted on a support structure 40. Support structure 40 includes a body 49 and two spaced apart supports 41 and 42. The end portions 14 and 16 of fiber Bragg grating 12 are bonded to the two spaced apart supports 42 and 41. The middle portion of the Bragg grating 12 is freely suspended between supports 41 and 42. In this embodiment an elongate slot 43 is provided along the length of the support structure 40. Members 46 and 47 are on either side of elongate slot 43 and form part of support structure 40. A mechanism such as a screw 48 is positioned at a point along its length and perpendicular to the axis of slot 43 such that adjustment of the screw 48 causes the elongate slot 43 to be opened more or less. The accompanying deformation will cause the support structure to deform in such a way that the supports 41 and 42 rotate about an effective hinge at 44 and 45 which are partial extensions of supports 41 and 42 at opposed ends of the slot 43. Accordingly adjustment of the screw 48 causes relative rotation of the spaced apart supports 41 and 42 and displacement of the end points 14 and 16 of the fiber Bragg grating 12. The support structure 40 can be designed such that compliance in the members 46 and 47 formed by the slot provides enhanced control of the support rotation with the screw. The controlled rotation of the supports 41 and 42 will allow the tension in the grating 12 to be controlled precisely.

A third embodiment of a tension control mechanism is shown in Figures 3 and 4 where the fiber Bragg grating is mounted on a support structure

50 as in the above embodiments. The end portions 14 and 16 of fiber Bragg grating 12 are bonded to two spaced supports 52 and 51 forming part of the support structure 50. The middle portion of the Bragg grating 12 is freely suspended between supports 51 and 52. In this embodiment the grating tension control is obtained by controlling the deformation at a slot 55 in the main body 54 of the support structure 50. Slot 55 is perpendicular to the longitudinal axis of the main body 54. The slot 55 extends across the width of the main body (as shown in Figure 4) and only part of the way through its thickness. A screw 58 in a tapered hole or some other wedge mechanism can be used to open the slot in a controlled manner such that the main body bends at the effective hinge location 53 and the supports undergo a rotation. Accordingly adjustment of screw 58 causes rotation of the main body 54 on each side of slot 55 and displacement of the end portions 14 and 16 of fiber Bragg grating 12. The resultant effect is a controlled reduction of the tension in the grating 12 and thereby control of the grating center wavelength.

A fourth embodiment of a tension control mechanism is shown generally at 60 in Figures 5 and 6 which is similar to that shown in Figure 1. Tension control mechanism 60 includes a body 62 with two spaced apart supports 64 and 66 at each end thereof. In addition body 62 has two spaced apart side walls 68 and 70 with a groove 72 therebetween. The end portions 14 and 16 of fiber Bragg grating 12 are bonded to the two spaced apart supports 64 and 66. The middle portion of the grating 12 is freely suspended between supports 64 and 66 over groove 72.

Support 64 is provided with two spaced apart arms 74 and 76

defining a slot 78 therebetween and the distance between the arms can be adjusted using an adjustment set-screw 80. A lateral slot 84 is provided at the end of support 64.

Groove 72 has a step portion 86 at the end thereof. A lateral groove 88 is formed in the side walls spaced from the end of body 62 and above step portion 86. Support 66 is a generally cross shaped member that sits on step portion 86 and is positioned in lateral groove 88. The elongate portion 90 of cross shaped support 66 is spaced above groove 72 and spaced inwardly from side walls 68 and 70. Support 66 may function as a thermal compensation bar such that the thermal response of the Bragg grating is annulled. A center groove 92 is provided in support 64 and 66 and fibre Bragg grating 12 is positioned therein and attached thereto.

As in the embodiment described above with regard to Figure 1, adjustment of the adjustment set-screw 80 displaces arm 74 either toward or away from arm 76. The slot 78 in the support 64 between arms 74 and 76 allows the inside edge 82 of the support to rotate counter clockwise when the screw 80 is advanced and clockwise when the screw 80 is retracted. Counter clockwise rotation of edge 82 serves to advance the upper edge to which the optical fiber is bonded and hence reduces the tension in the grating and clockwise rotation of edge 82 has the opposite effect. Accordingly, adjustment of screw 80 causes rotation and bending of the arms 74 and 76 and displacement of the end portion 14 of the fiber Bragg grating 12.

In the embodiment shown in Figures 5 and 6 body 62 is made of invar and support 66 is made of brass. Alternatively the support is made of

stainless steel. The overall length of body 62 is 50 mm. The length of support 66 is 15 mm, of support 64 is 13 mm, and of slot 78 is 12 mm. The height of the slot is 0.6 mm. The middle portion of fiber Bragg grating 12 is 22 mm. With the embodiment as described herein provides a tuning range of approximately 0 - 0.2 nanometers of the fiber Bragg grating center wavelength.

It will be appreciated by those skilled in the art that the tension control mechanism of the present invention can be used in a number of applications. Specifically it would be to produce a tunable filter wherein the fiber Bragg grating center wavelength is tunable on the order of one or several nanometer including between about 0 and about 9 nanometers. This would have specific application in regard to WDM optical transmission systems or optical test and measurement applications. Alternatively the tension control mechanism of the present invention can be used as a fine tuning device wherein the filter spectral position is optimized. Accordingly, when the mechanism is used for fine tuning it may be designed to be used in a range of 0 to 0.5 nanometers or, as in the example shown in Figure 5, 0 to 0.2 nanometers.

The foregoing description of the preferred embodiments of the invention has been presented to illustrate the principles of the invention and not to limit the invention to the particular embodiment illustrated. It is intended that the scope of the invention be defined by all of the embodiments encompassed within the following claims and their equivalents.

THEREFORE WHAT IS CLAIMED IS:

1. A tension control mechanism for controlling the spectral properties of a fiber Bragg grating, comprising:

an adjustable support structure attachable to the fiber Bragg grating at first and second attachment portions, the support structure having an adjustment mechanism whereby adjustment of the support structure in one direction increases tension in the fiber Bragg grating and adjustment of the support structure in the other direction decreases tension in the fiber Bragg grating.

2. The tension control mechanism according to claim 1 wherein said support structure includes a body and first and second spaced apart supports and the first attachment portion for the fiber Bragg grating is on the first support and the second attachment portion for the fiber Bragg grating is on the second support whereby the fiber Bragg grating between the first and second attachment portions includes a suspended portion therebetween.

3. The tension control mechanism according to claim 2 wherein the first support member includes a forked structure including first and second arms joined at one end thereof defining a slot therebetween and the adjustment mechanism adjusts the width of the slot between the first and second arms thereby creating an effective hinge at the joined end of the first and second arms and whereby adjustment of adjustment mechanism causes relative rotation of the first and second arms and relative displacement of the first and second attachment

portion of the fiber Bragg grating.

4. The tension control mechanism according to claim 3 further including first and second spaced apart side walls extending upwardly from the body between the first and second spaced apart supports and defining a groove therebetween.

5. The tension control mechanism according to claim 4 wherein a lateral slot is formed in the first and second side walls proximate to the first support.

6. The tension control mechanism according to claims 4 or 5 wherein the second support is a generally cross shaped member attached to the body, the cross shaped member having an elongate portion that is spaced above the groove and inwardly from the first and second side walls.

7. The tension control mechanism according to claims 3, 4, 5 or 6 wherein the adjustment mechanism includes an adjustment screw connected between the first and second arms whereby adjustment of the adjustment screw displaces the first arm toward or away from the second arm and the fiber Bragg grating is attached to the first arm.

8. The tension control mechanism according to claims 6 or 7 wherein the body is made of invar and the cross shaped member is made of brass.

9. The tension control mechanism according to claim 2 wherein the body has a length and the body includes an elongate slot formed along the length having

first and second members on either side thereof which are connected at opposed ends thereof and the adjustment mechanism adjusts the width of the elongate slot whereby adjustment of adjustment mechanism causes relative rotation of the first and second spaced apart supports and relative displacement of the first and second attachment portions of the Bragg grating.

10. The tension control mechanism according to claim 9 wherein the adjustment mechanism includes an adjustment screw connected between the first and second members.

11. The tension control mechanism according to claim 2 wherein the body has a width and a thickness, the body includes a slot formed through its width and partially through the thickness from one side thereof and the adjustment mechanism adjusts the width of the slot whereby adjustment of adjustment mechanism causes relative rotation of the body on each side of the slot and relative displacement of the first and second attachment portions of the Bragg grating.

12. The tension control mechanism according to claim 11 wherein the adjustment mechanism includes an adjustment screw positioned in the slot.

13. The tension control mechanism according to any of the preceding claims wherein selective increase and decrease in the tension in the fiber Bragg grating adjusts the fiber Bragg grating center wavelength in a range of about 0 to about 9 nanometers.

14. The tension control mechanism according to any of the preceding claims wherein selective increase and decrease in the tension in the fiber Bragg grating adjusts the fiber Bragg grating center wavelength in a range of about 0 to about 0.5 nanometers.

15. The tension control mechanism according to any of the preceding claims wherein selective increase and decrease in the tension in the fiber Bragg grating adjusts the fiber Bragg grating center wavelength in a range of about 0 to about 0.2 nanometers.

16. A tension controlled fiber Bragg grating assembly comprising a tension control mechanism according to any of the preceding claims and an optical fiber having a Bragg grating wherein the fiber Bragg grating is attached to the adjustable support structure.

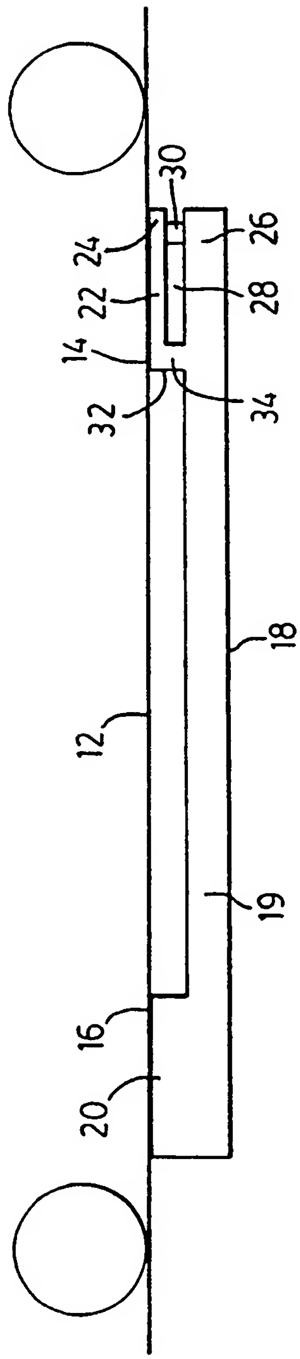
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FIG. 1

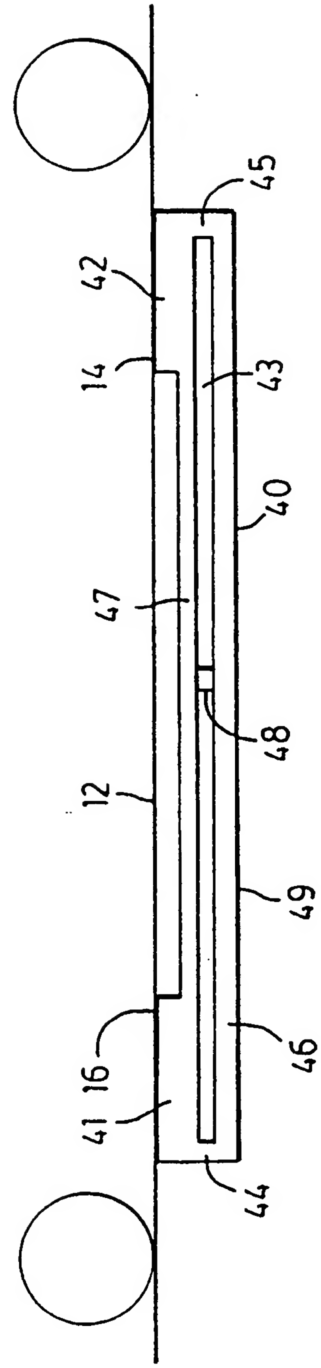
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FIG. 2

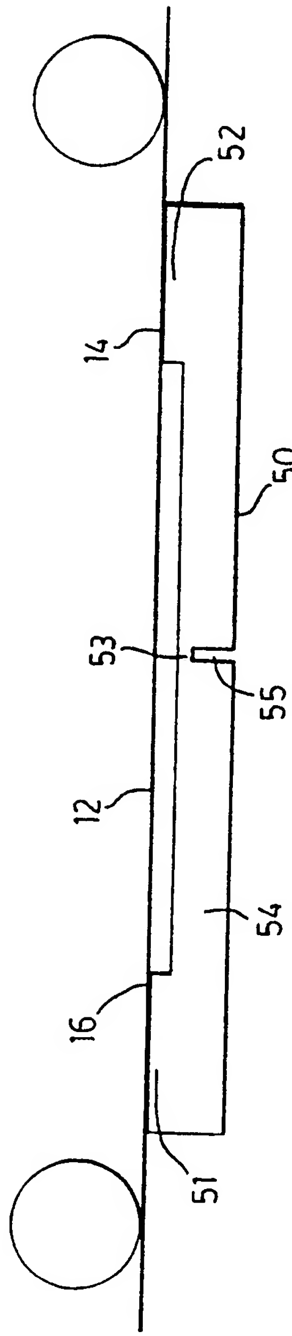

FIG. 3

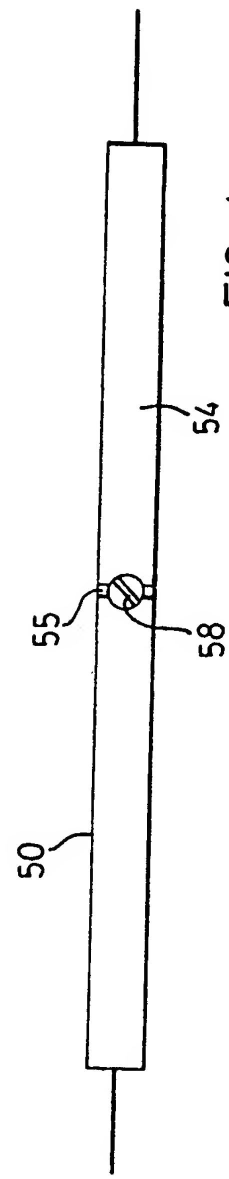

FIG. 4

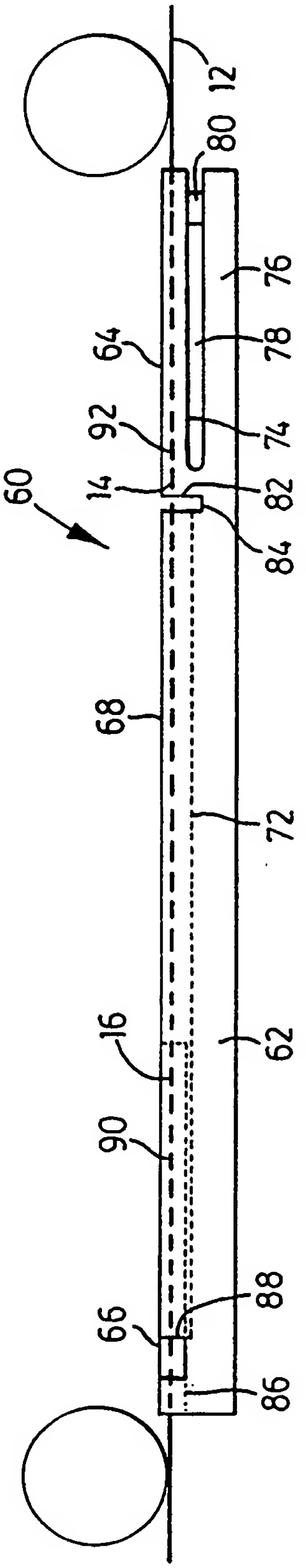
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FIG. 5

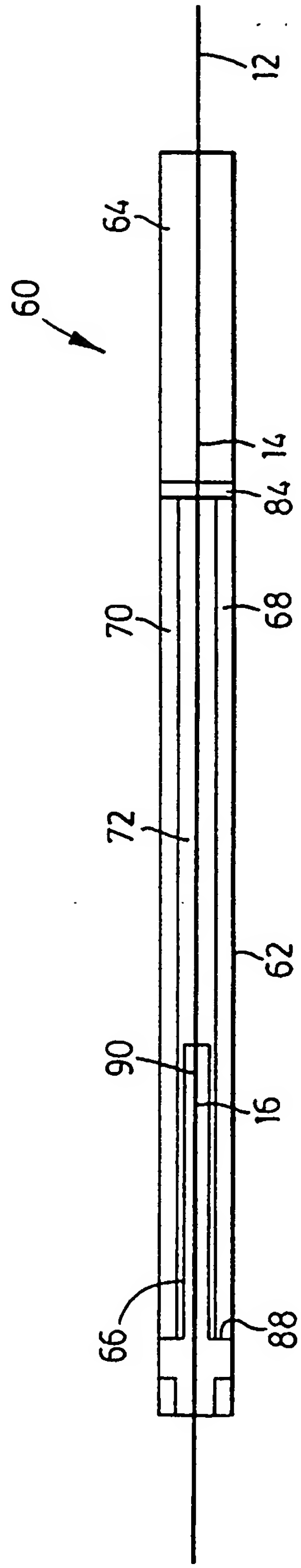
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FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 00/00253

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B6/16 G02F1/01

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 774 619 A (H.BRUESSEBACH) 30 June 1998 (1998-06-30) abstract; figures 1-6	1,7,9-12
A	WO 91 10151 A (UNITED TECHNOLOGIES) 11 July 1991 (1991-07-11) cited in the application abstract; figures 1-4	1
A	US 5 682 445 A (R.H.SMITH) 28 October 1997 (1997-10-28) abstract; figures 1-12	1
A	US 5 841 920 A (P.J.LEMAIRE ET AL.) 24 November 1998 (1998-11-24) abstract; figures 1-6	1

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 5 991 483 A (J.W.ENGELBERTH) 23 November 1999 (1999-11-23) the whole document -----	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 00/00253

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